REMARKS

This Preliminary Amendment amends the originally-filed Abstract of the above-referenced U.S. application, and provides the amended Abstract on a separate sheet. In addition, the Preliminary Amendment amends the originally-filed specification of the above-referenced U.S. application, via a Substitute Specification, to refer to and claim priority from the underlying PCT Application No. PCT/JP2004/016651 which was filed on November 10, 2004 and published on May 19, 2005 as International Publication No. WO 2005/044481, and from Japanese Patent Application No. 2003-381285, filed November 11, 2003, and Japanese Patent Application No. 2004-264022 filed September 10, 2004, pursuant to 37 C.F.R. § 1.78(a)(2). In addition, the specification has been amended to remove minor informalities from originally-filed PCT application, as provided herewith in the enclosed Substitute Specification. A marked-up comparison documents between the English language translation of the originally-filed specification and the Substitute specification is enclosed herewith. The title of the PCT Application No. PCT/JP2004/016651 has also been deleted, and a new title provided as set forth herein above.

Further, originally-filed claims 1-10 of the underlying PCT Application No. PCT/JP2004/016651 and substitute claims submitted pursuant to PCT Article 34 have been cancelled, without prejudice, and new claims 11-20 have been added to provide the substitute claims 1-10 in an appropriate form for prosecution before the U.S. Patent and Trademark Office, and not due to any reason of patentability. Accordingly, claims 11-20 are now under consideration in the above-identified application. It is respectfully submitted that the amendments to the specification and new claims do not add new matter to the application.

The underlying PCT Application No. PCT/JP2004/016651 includes an International Search Report, dated February 22, 2005, a copy of which is included. The Search Report includes a list of document(s) that have been considered by the Examiner in the underlying PCT application.

Enclosed herewith, please also find a copy of the PCT Written Opinion for the International Application No. PCT/JP2004/016651 dated February 22, 2005. In addition, the PCT Preliminary Examination Report for the underlying PCT Application No. PCT/JP2004/016651 dated March 10, 2006 is also enclosed.

Applicants assert that the present invention is new, non-obvious, and useful. Prompt consideration and allowance of the pending claims are respectfully requested.

Respectfully submitted,

Dated: May 11, 2006

By: _____

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TO ALL WHOM IT MAY CONCERN:

Be it known that we, **NORIYUKI SUZUKI, AKIHIRO UENISHI, YUKIHISA KURIYAMA, TOSHIYUKI NIWA, TAKUYA KUWAYAMA and MITSUHARU YAMAGATA**, all are citizens of Japan, whose post office address is c/o NIPPON STEEL CORPORATION, Technical Development Bureau, 20-1, Shintomi, Futtsu-shi, Chiba 293-8511 JAPAN, have invented an improvement in

PRESS-FORMING DEVICE, PRESS-FORMING METHOD, COMPUTER PROGRAM PRODUCT AND STORAGE MEDIUM

~~SUBSTITUTE SPECIFICATION~~ SPECIFICATION

PRESS-FORMING DEVICE, PRESS-FORMING METHOD, COMPUTER PROGRAM PRODUCT AND STORAGE MEDIUM

~~PRESS-FORMING DEVICE, PRESS-FORMING METHOD, COMPUTER PROGRAM PRODUCT AND STORAGE MEDIUM~~

CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] This application is a national stage application of PCT Application No. PCT/JP2004/016651 which was filed on November 10, 2004 and published on May 19, 2005 as International Publication No. WO 2005/044481 (the "International Application"), the entire disclosure of which is incorporated herein by reference. This application claims priority from the International Application pursuant to 35 U.S.C. § 365. The present application also claims priority under 35 U.S.C. § 119 from Japanese Patent Application No. 2003-381285, filed November 11, 2003, and Japanese Patent Application No. 2004-264022 filed September 10, 2004, the entire disclosures of which are incorporated herein by reference.

~~Technical Field~~

FIELD OF THE INVENTION

[0002] ~~[0001]~~ The present invention relates to a press-forming device, a press-forming method, a computer program and a storage medium, ~~and in particular, relates to a suitable technology~~e.g., to be used for ~~a favorable~~ processing irrespective of characteristic deviation of various metal materials such as iron series, nonferrous series, stacked materials and the like, or environmental fluctuations during processing.

~~Background Art~~
BACKGROUND INFORMATION

[0003] ~~[0002]~~ Conventionally, when performing deep-drawing, bending, cutting, or the like to a metal material, using a press-forming device, it is usual to carry out actual production after determining appropriate forming conditions, namely, processing conditions such as the shape of metal molds, lubricating conditions, forming speed, blank holding force, the temperature of metal molds and work, ~~and so on~~etc. for every metal material in advance by trial production through experience, or through experiment, or by simulation or the like using a finite-element method.

[0004] ~~[0003] Whereas, various~~Various metal materials being a raw material ~~are~~can be plates, pipes, bars, wires, powder or grains, and the like obtained through multiple processes of melting-smelting-casting-rolling-heat treatment-secondary processing and so on from raw material or scraps, and there inevitably exists some extent of deviation in mechanical properties in a product due to fluctuation of chemical components, or fluctuation of processing conditions such as uneven temperatures.

[0005] ~~[0004]~~ Accordingly, even when appropriate forming conditions are determined in advance as described above, occurrence of forming defect may arise due to differences in

formability according to material positions or production lot numbers. In order to avoid this defect, an execution of quality control during material production process is performed more severely~~, but excess~~. However, such severity may lead to a material cost increase, and ~~is~~may not be recommendable.

[0006] ~~[0005]~~ Moreover, even when the mechanical characteristics of the raw material are identical, occurrence of forming defect may arise due to environmental fluctuation during processing such as temperature change of metal mold caused by continuous operation, abrasion of metal mold, fluctuation of atmospheric temperature or humidity.

[0007] ~~[0006]~~ As a countermeasure against these disadvantages, various inventions for a press-forming method to control processing conditions according to metal material or conditions of a metal mold have been disclosed. For ~~instance, in Patent Document 1, disclosed~~example, Japanese Patent Application Laid-open No. Hei 7-266100 describes is a device to control air pressure in an air cylinder to carry out press-forming under an appropriate blank holding force. This is described as being performed by determining in advance a relation between a physical quantity such as a shape of press material and its mechanical property, chemical property, a laminate layer property of plating or the like, and surface conditions such as

oil quantity or the like; and an appropriate blank holding force from which prescribed press quality is obtained; and by determining the appropriate blank holding force according to actual physical quantity from the above-described relation.

[0008] ~~[0007] Patent Documents 2 and 3 disclose~~Japanese Patent Application Laid-open Nos. Hei 5-285700 and Hei 6-246499 describe a device which adjusts press conditions based on machine information and metal mold information peculiar to a press machine. ~~[0008] Patent Documents 4, 5, and 6 disclose~~ Japanese Patent Application Laid-open Nos. Hei 7-265957, Hei 10-128451 and Hei 8-300048 describe various methods to adjust to prescribed bending angles in a bending process using a press brake.

[0009] ~~[0009] The inventions disclosed in Patent Documents 1 to 3 and the like are~~Japanese Patent Application Laid-open Nos. Hei 7-266100, Hei 5-285700 and Hei 6-246499 provide descriptions which are generally aimed at controlling blank holding force based on material characteristics, information peculiar to a machine, and metal mold information. However, since lubrication characteristics, especially with metal molds, may vary from one moment to ~~moment~~the next by the synergistic effect of the fluctuation of material characteristics and the fluctuation of

machine and mold conditions, it ~~is very~~may be difficult to estimate ~~it~~the force in advance.

[0010] ~~[0010] The inventions disclosed in Patent Documents 4 to 6 are~~The description of Japanese Patent Application Laid-open Nos. Hei 7-265957, Hei 10-128451 and Hei 8-300048 are generally aimed at adjusting the processing conditions according to the state of deformation during processing of the work in a bending process, but it is difficult to measure complicated three-dimensional shape on the spot in drawing or cutting. Further, since material is cramped with a metal mold during drawing or cutting, ~~there have been very difficult~~ problems may exist in measuring the material shape precisely.

[0011] ~~[0011] The~~One of the objects of the present invention ~~has been made in view of~~is to overcome and/or address the above-described problems, and ~~the object of the invention is to find a method~~to provide a way to perform satisfactory press-forming while compensating deviation of various material characteristics and environmental fluctuation during processing.

[0012] ~~[0012]~~

[0013] ~~Patent Document 1: Japanese Patent Application Laid-open No. Hei 7-266100~~

[0014] ~~Patent Document 2: Japanese Patent Application Laid-open No. Hei 5-285700~~

[0015] ~~Patent Document 3: Japanese Patent Application Laid-open No. Hei 6-246499~~

[0016] ~~Patent Document 4: Japanese Patent Application Laid-open No. Hei 7-265957~~

[0017] ~~Patent Document 5: Japanese Patent Application Laid-open No. Hei 10-128451~~

[0018] ~~Patent Document 6: Japanese Patent Application Laid-open No. Hei 8-300048~~

SUMMARY OF EXEMPLARY EMBODIMENTS OF THE INVENTION

[0019] ~~Summary~~An exemplary embodiment of ~~the Invention [0013] The~~ press-forming device and ~~the~~ method ~~of~~according to the present invention ~~are~~can be provided to obtain a satisfactory press molding product. For example, this can be done by grasping and computation controlling ~~at least two or more means~~a plurality of arrangements out of a material characteristic input ~~means~~arrangement, a material characteristic measurement ~~means~~arrangement, or a state variable detector for the fluctuation of material characteristics or lubrication characteristics between a metal mold and a work~~,~~ (which ~~are conventionally~~have been previously difficult to estimate).

[0020] ~~[0014] The~~According to one exemplary embodiment of the press-forming device of the present invention ~~is a press-forming~~

~~device having~~, the press-forming device may have a punch, die and blank holder~~, and press-forming a~~. A material can be press-formed according to a ~~prescribed~~predetermined forming condition~~, including:~~

[0021] ~~at least two or more means of~~ . For example, the press-forming device can include a plurality of arrangements, a material characteristic input ~~means~~arrangement capable of inputting at least one material characteristic out of material characteristics of sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness, of the material~~;~~ . In addition, a material characteristic measurement ~~means~~arrangement can be provided for measuring at least one material characteristic out of material characteristics of sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, and lubricant film thickness, of the material before forming~~; or~~ . Alternatively or in addition, a state variable detector may be provided for measuring at least one state variable out of the state variables of punch reaction, metal mold temperature, metal mold distortion

amount, work piece deformation amount, or work piece temperature during forming the material~~;~~.

[0022] ~~and further comprising:~~

[0023] In addition, a processing condition computer ~~computing~~may be provided which is configured to determine at least one processing condition out of the processing conditions ~~of~~for forming speed, blank holding force or metal mold temperature from at least two or more pieces of information out of material characteristics inputted by the material characteristic input ~~means~~arrangement, material characteristics measured by a material characteristic measurement means or a material state variable during forming measured by the state variable detector~~;~~ ~~and~~ . In addition, a processing condition controller ~~controlling~~may be provided which is configured to control at least one processing condition out of the process conditions including punch or die movement speed, metal mold temperature or blank holding force based on the processing condition ~~computed~~determined by the processing condition computer.

[0024] ~~[0015] Another characteristic of the press-forming device~~According to one exemplary variant of the present invention ~~is that~~, the material characteristic input ~~means includes any one of or a combination~~arrangement can include one or more of a manual input device, a bar code reader, an IC tag

reader, a flexible disc and/or a ~~photomagnetic~~photo-magnetic disc reader.

[0025] ~~[0016] A press-forming method~~In another exemplary embodiment of the present invention ~~is a press-forming method using~~, a press-forming method can be provided which can use a press-forming device having a punch, die and blank holder, and press-forming a material according to a prescribed forming condition. For example, ~~including the steps of:~~

[0026] ~~at least two or more of inputting at~~at least one material characteristic out of the material characteristics of sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness of the material can be inputted. At least one material characteristic out of the material characteristics of sheet thickness~~, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness of the material;~~

[0027] ~~measuring at least one material characteristic out of the material characteristics of sheet thickness before forming, yield strength, 0.2% proof stress, tensile strength, elongation,~~

~~n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness of the material before forming; or measuring at~~ can be measured before forming, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness of the material before forming. At least one state variable out of the state variables can be formed of the punch reaction, metal mold temperature, metal mold distortion amount, work piece deformation amount, or work piece temperature, during forming the material~~;~~.

[0028] ~~and further comprising the steps of: computing~~In addition or alternatively, at least one processing condition out of the processing conditions ~~of~~can be determined for forming speed, blank holding force or metal mold temperature from at least two or more pieces of information out of material characteristics inputted ~~by the material characteristic input step~~, material characteristics measured by a material characteristic measurement step or a material state variable ~~during forming measured by~~when the state variable ~~detection step; and controlling at~~is formed. At least one control condition out of the processing conditions including punch or

die movement speed, metal mold temperature or blank holding force can be controlled based on the processing condition ~~computed by the processing condition computation step~~.

[0029] ~~Another characteristic of the press-forming method~~According to another variant of the present invention~~ is to take in~~, the punch reaction maximum value can be obtained during forming into ~~a~~the computer for every prescribed number of times in the processing condition control process. This can be done to ~~calculate~~determine the moving average value of the punch reaction maximum value. For example, ~~and~~ when the calculated punch reaction maximum value deviates from the prescribed value, ~~control to change~~ the blank holding force ~~is performed~~can be changed.

[0030] ~~Still~~According to yet another ~~press-forming method~~exemplary embodiment of the present invention~~ is a~~, another press-forming method ~~using~~can be provided that may use a press-forming device having a punch, die and blank holder, and press-forming a material according to a prescribed forming condition. For example, ~~including the steps of: measuring~~ at least one or more state variables out of the state variables ~~of~~may be measured for obtaining punch reaction, metal mold temperature, metal mold distortion amount, work piece deformation amount or work piece temperature, for every forming

of material~~; computing at~~. At least one processing condition out of one kind or two or more kinds of processing conditions ~~of~~may be determined for forming speed, blank holding force, or metal mold temperature according to comparison result with the past state variables~~; controlling at~~. At least one or more processing conditions out of the processing conditions including a punch or die movement speed, metal mold temperature, or blank holding force can be controlled based on the processing conditions ~~computed by the processing condition computation step~~.

[0031] ~~Still another characteristic of the press-forming method~~In one exemplary variant of the present invention ~~further including the steps of: inputting~~, at least one material characteristic out of the material characteristics of sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness~~,~~ of the material~~, in which the~~ may be provided. At least one processing condition ~~computation step computes at least one processing condition~~ out of the processing conditions ~~of~~can be determined for the forming speed, blank holding force, or metal mold temperature from material characteristics inputted in the material characteristic input

process and a material state variable for every forming processing ~~measured by the state variable detection step. Yet another characteristic of the press-forming method of the present invention is that the~~performed by the measurement of the state variable. The comparison result with the past state variables ~~is the~~may be obtained as a result of comparing the difference between the past state variable and that of the present value, and the moving average value and the prescribed value within a prescribed time period or a prescribed number of times.

[0032] ~~[0017] A computer program product of the present invention is a computer program product to be used in a computer for a press-forming method~~According to a further exemplary embodiment of the present invention, a computer program/software arrangement can be provided. For example, the computer program/software arrangement can be stored on a storage medium and/or may be accessed by a processing arrangement for performing a press-forming technique using a press-forming device having a punch, die and blank holder, and press-forming a material according to a ~~prescribed forming condition, including: at least two or more steps of~~

[0033] ~~a material characteristic input process to input at least one material characteristic among the following~~

~~characteristics: material sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, and lubricant film thickness;~~

[0034] ~~a material characteristic measurement process to measure at least one material characteristic among the following characteristics: material sheet~~

[0035] ~~thickness before forming, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, and lubricant film thickness, or~~

[0036] ~~a state variable detection process to measure at least one state variable among the following state variables: punch reaction, metal mold temperature, metal mold distortion amount, work piece deformation amount, and work piece temperature during forming the material,~~

[0037] ~~and the steps to be executed in a computer, comprising:~~

[0038] ~~computing at least one processing condition out of the processing condition of forming speed, blank holding force and metal mold temperature from at least two or more pieces of information out of material characteristics inputted by the~~

~~material characteristic input step, material characteristics measured by the material characteristic measurement step or material state variable during forming process measured by the state variable detection step, and controlling at least one processing condition out of the processing conditions including punch or die movement speed, metal mold temperature or blank holding force based on the processing condition computed by the processing condition computation step.[0018] A storage medium of the present invention is~~predetermined forming condition. For example, the computer program/software arrangement can perform the procedures described above for the exemplary methods of the present invention when the computer program/software arrangement is executed by a processing arrangement. In a still further exemplary embodiment of the present invention, a storage medium (e.g., a computer readable recording medium ~~on which a program product is recorded, the program product for a press-forming method using a punch, die and blank holder, and press-forming a material according to a prescribed forming condition, including:~~) can be provided which may provide or store thereon a computer program product/software arrangement described above.

[0039] ~~at least two or more steps of~~

[0040] ~~inputting at least one material characteristic out of the material characteristics of sheet thickness, yield strength,~~

~~0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, or lubricant film thickness of the material;~~

[0041] ~~measuring at least one material characteristic out of the sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, stress-strain relation equation, hardness, temperature, surface roughness, friction coefficient, and lubricant film thickness of the material before forming, or~~

[0042] ~~measuring at least one state variable out of the state variables of punch reaction, metal mold temperature, metal mold distortion amount, work piece deformation amount, and work piece temperature during forming the material,~~

[0043] ~~and the steps to be executed in a computer, comprising:~~

[0044] ~~computing at least one forming condition out of the processing conditions of forming speed, blank holding force or metal mold temperature from at least two or more pieces of information out of material characteristics inputted by said material characteristic input process, material characteristics measured by said material characteristic measurement process or~~

~~material state variable during forming process measured by said state variable detection process, and~~

[0045] ~~controlling at least one processing condition out of the processing conditions including punch or die movement speed, metal mold temperature and blank holding force based on the processing condition computed in the processing condition computation step.~~

[0046] These and other objects, features and advantages of the present invention will become apparent upon reading the following detailed description of embodiments of the invention, when taken in conjunction with the appended claims.

~~Brief Description of the Drawings~~
~~[0019]~~
BRIEF DESCRIPTION OF THE DRAWINGS

[0047] Further objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figure showing illustrative embodiment(s), result(s) and/or feature(s) of the exemplary embodiment(s) of the present invention, in which:

[0048] Fig. 1 is a ~~view showing a diagrammatic structure~~structural and flow diagram of a press-forming device ~~of~~according to an exemplary embodiment of the present invention;

[0049] Fig. 2 is a flow chart ~~showing a~~of a press-forming procedure ~~of the press-forming~~according to an exemplary embodiment of the present invention;

[0050] Fig. 3 is ~~a view showing an example of~~an exemplary table providing an influence function matrix relating to material characteristics and standard processing conditions according to the exemplary embodiment of the present invention;

[0051] Fig. 4 is ~~a view showing an example of~~an exemplary table providing an influence function matrix relating to state variables and corrected processing conditions according to the exemplary embodiment of the present invention;

[0052] Fig. 5 is ~~a view showing an example of~~an exemplary table providing reference values of material characteristics according to the exemplary embodiment of the present invention;

[0053] Fig. 6 is ~~a view showing~~ an exemplary table providing an example of standard processing conditions according to the exemplary embodiment of the present invention;

[0054] Fig. 7 is ~~a view showing~~an exemplary table providing another example of an influence function matrix relating to material characteristics and standard processing conditions according to the exemplary embodiment of the present invention;

[0055] Fig. 8 is ~~a view showing~~ an exemplary table providing an example of reference values of state variables according to the exemplary embodiment of the present invention;

[0056] Fig. 9 is ~~a view showing~~an exemplary table providing another example of an influence function matrix relating to state variables and corrected processing conditions according to the exemplary embodiment of the present invention;

[0057] Fig. 10 is ~~a~~an elevation view ~~showing an example to attach~~of an IC tag provided for attaching to a cut plate package according to the exemplary embodiment of the present invention;

[0058] Fig. 11 is ~~a~~an elevation view ~~showing an example to attach~~of an IC tag provided for attaching to a material coil according to the exemplary embodiment of the present invention;

[0059] Fig. 12 is ~~a~~an elevation view ~~showing an example to attach~~of a bar code provided for attaching to a cut plate material according to the exemplary embodiment of the present invention; and

[0060] Fig. 13 is a ~~characteristic figure showing a relation~~graph showing an exemplary relationship between punch reaction and blank holding force according to the exemplary embodiment of the present invention.

[0061] Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the present invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments.

~~Detailed Description of the Preferred Embodiments~~
DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE INVENTION

~~[0020] First~~**Exemplary Embodiment~~-~~

[0062] Hereinafter, ~~preferable~~exemplary embodiments of a press-forming device, a press-forming method, a computer program/software arrangement, and a storage medium ~~of~~according to the present invention will be explained referring to the drawings. ~~Fig. 1 shows a diagrammatic structure of a press-forming device of an embodiment to which the present invention is applied.~~

[0063] ~~[0021] More concretely, in~~For example, Fig. 1 shows a structural and flow diagram of a press-forming device ~~5, "1" denotes a punch, "2" denotes a die, "3" denotes~~5 of an exemplary embodiment of the present invention. This exemplary press-forming device 5 includes a punch 1, a die 2, a blank holder~~,~~ ~~and "6" denotes~~ 3 and a metal mold device~~. "7" denotes a~~ 6. One or more state variable ~~sensor~~sensors (load cell)~~,~~ 7 and

~~other than these, there is provided~~ a state variable sensor (a thermocouple)~~. "10" denotes~~ are also provided. The punch 1 may be associated with an air cylinder~~, "11" denotes~~ 10, and a hydraulic cylinder~~,~~ 11 and ~~"12" denotes~~ a heater~~.~~ 12 can be included in the press-forming device 5.

[0064] ~~[0022] "15" denotes a material characteristic reader~~A material characteristic reader 15 can be provided which includes a material characteristic reader (IC tag reader) 9 and a material characteristic reader (controller) 14.~~[0023] "13"~~ The press-forming device 5 may further include denotes a hydraulic controller~~. "16" denotes~~ 13, a state variable detection device~~. "17" denotes~~ 16, and a blank holding force controller~~.[0024] "22" denotes a~~ 17. A control computer~~,~~ ~~which includes~~ arrangement 22 can be provided to cooperate with the press-forming device 5. The computer arrangement 22 may include a standard material characteristic storage device 18, a reference state variable storage device 19, a standard processing condition storage device 20, and an arithmetic ~~unit~~arrangement 21. The control computer ~~22~~arrangement 22 according to an exemplary embodiment of the present embodiment ~~is composed of~~can include a computer system ~~including a~~ with, e.g., a central processing unit (CPU), a random access memory (RAM) and a read-only memory (ROM), ~~and~~along with a processing

condition controller, a material characteristic input ~~means~~arrangement (e.g., hardware or program/software arrangement), a state variable detector (e.g., hardware or program/software arrangement), a processing condition computer arrangement (e.g., hardware or program/software arrangement), a material characteristic measurement ~~means, and the like of the present embodiment are programmed by the computer system~~arrangement (e.g., hardware or program/software arrangement), etc. For example, these exemplary hardware or program/software arrangements may be accessed by the control computer arrangement 22 or another computing arrangement to program such arrangements to execute specific procedures effectuated by these or program/software arrangements.

[0065] ~~[0025]~~ ~~A~~ procedure of a press-forming method according to the exemplary embodiment of the present ~~embodiment will be explained next referring~~invention is described below with reference to Fig. 2. ~~A~~Information regarding the metal material is read or obtained by the above-described material characteristic reader 15 from an IC tag ~~(refer to~~101, 111 (show in Figs. 10 and ~~11~~11, respectively) or a bar code ~~(refer to~~121 (shown in Fig. 12) pasted on the surface of the metal material at a stage of being set to the press-forming device 5. The material characteristic information thus read or obtained is

~~inputted~~provided by the material characteristic input ~~means~~ ~~(Step~~arrangement (step S201). ~~Here~~For example, the material characteristic ~~is~~may be one ~~kind~~type or a combination of two or more ~~kinds~~types of the following exemplary characteristics: sheet thickness, yield strength, 0.2% proof stress, tensile strength, elongation, n value, r value, coefficient of stress-strain relation equation, table showing each point value approximated to the stress-strain relation with a line graph, hardness, temperature, surface roughness, friction coefficient, and lubricant film thickness ~~and so on~~, etc. for every material.

[0066] ~~[0026] As a means~~As one exemplary way to input or provide material characteristics, the material characteristics ~~are~~can be directly read ~~here~~ for every material from ~~a~~the bar code 121 or ~~an~~the IC tag~~.~~ 101, 111. When the amount of data is ~~great~~large, it is also ~~adoptable~~possible to read an ID (identification) number from ~~a~~the bar code 121 or ~~an~~the IC tag 101, 111, and receive or obtain the real valued data corresponding to the identification number from, e.g., a server via a network and/or to this number input directly from a mill sheet, a flexible disc ~~or the like~~, etc. attached from a material manufacturer for every coil material into the material characteristic input device.

[0067] ~~[0027]~~ ——In general, when performing the exemplary press processing procedure, since the material is cut in an appropriate size from, for ~~instance~~example, a coiled material before the material ~~is~~can be set in a press machine, and heat treatment or surface treatment is ~~given~~provided in ~~some~~certain exemplary cases, it ~~is often~~may be difficult to obtain the above-described material characteristic in advance.

[0068] ~~[0028]~~ ——For this ~~problem~~issue, it is possible to obtain further precise material characteristic information by directly measuring one kind or combination of two or more kinds among the above-described material characteristics, or ~~more~~ preferably, from easiness of measurement, one ~~kinds~~type or a combination of two ~~kinds~~ or more types out of sheet thickness, hardness, temperature, friction coefficient, and lubricant film thickness, before the material is set to ~~a~~the press-forming device 5 and/or ~~just~~ at the time of setting.

[0069] ~~[0029]~~ ——Then, initialization values of processing condition ~~are~~can be corrected (~~Steps~~steps S202, ~~and~~ S203) based on the ~~read~~obtained material characteristic values and the reference material characteristic values to the material recorded or stored in the reference material characteristic storage device 18 (or another data recording device) in advance. ~~Here, the~~The processing condition ~~is~~can be one ~~kinds~~type or a

combination of two or more ~~kinds~~types of forming speed, blank holding force, and metal mold temperature.

[0070] ~~[0030] — A concrete~~An exemplary embodiment of a correction method of a processing condition ~~will be shown next. Material~~according to the present invention is described below. For example, material characteristic values to the respective material characteristics ~~are~~can be taken respectively as P(j) (j = 1-M~~,~~, where M is the number of the material characteristic values), and the reference values for the respective material characteristics ~~are~~may be taken as ~~PO~~P0 (j) (j = 1-M). The initialization values to the above-described respective standard processing conditions ~~are~~can be taken respectively as ~~CO~~C0(i) (i = 1-L, where L is the number of processing condition set values). An influence function matrix which indicates the relation between the deviation of the material characteristic of a material from its reference value and the amount of correction of the processing condition ~~is~~may be taken as T1 (I, j), and the initialization value of the processing condition ~~is~~can be corrected with the following equation ~~(1).~~:

~~C0~~C0(i) (after correction) = ~~CO~~C0(i) (initialization value)~~×~~ *

$$(1+\Sigma\Sigma\,(T1(ij)\times^{*}(P(j)/^{PO}P0(j)-1)))$$

$$(i = 1\text{-}L,\ j = 1\text{-}M)\cdots \qquad (1)$$

[0071] ~~[0031]~~ ——The setting value ~~C0~~C0(j) of the standard processing condition may be a fixed value during forming, and when it is changed during forming, for instance, a setting value to each punch stroke amount may be given. A formation example of the influence function matrix T1 is shown in an exemplary table of Fig. 3. When the sheet thickness is, for ~~instance~~example, thicker than the reference value by 1%, the function of T1 ~~corresponds~~can correspond to that the forming speed and blank holding force are increased by 0.2% and 0.4% respectively, and there ~~is~~may be no change for the metal mold temperature, using the equation (1).

[0072] ~~[0032]~~ ——Each component of the influence function matrix can be determined from the following exemplary methods: a method to determine from the change (sensibility analysis) of the optimum forming condition to the change of various material characteristics using a forming simulation by a finite element method; a method to statistically determine from a relation between material characteristic variation and processing condition, product quality (cracks, creases, spring back, surface distortion, and the like) in actual mass production press process; a method to input actual measurement value on product quality into the press-forming device as instruction data and prepare and update using, for instance, a learning

function by a neural network; or the like. ~~Note that~~The formation of material characteristic value and processing condition or formulation method is not limited to the above described procedures and descriptions, and ~~arbitral~~arbitrary setting is also adoptable.

[0073] ~~[0033]~~ Then, based on initial processing conditions, using the blank holding force controller, a forming speed controller, and a metal mold temperature controller, a load is applied on the blank holder, an upper metal mold ~~is~~may be descended and the forming ~~is~~procedure can be started (~~Step~~step S204). ~~Note that~~The controllers are not limited to ~~these~~those described above, other controlling ~~means~~arrangements, either single or a combination of multiple ~~means,~~arrangement, in any arbitrary form ~~is adoptable~~may be used.

[0074] ~~[0034]~~ During the processing procedure, using the state variable detection device 16, at least one state variable out of punch reaction, metal mold temperature, metal mold distortion amount, work piece deformation amount, work piece temperature, ~~and the like is~~etc. may be measured, and the processing condition ~~is~~can be corrected from one moment to another moment by ~~a~~the processing condition computer (~~Steps~~see steps S205 ~~to~~ S208).

[0075] ~~[0035] Concretely~~In particular, the processing conditions ~~are~~can be corrected ~~from moment to moment~~ according to the following exemplary equation ~~(2),~~:

$$C(i) = \text{~~CO~~}C0(i) \text{~~*~~}* (1+\text{~~Σ~~}\Sigma (T2(i,k) \text{~~*~~}* (S(k)/\text{~~SO~~}S0(k)-1))) \quad (i = 1\text{-}L,\ k = 1\text{-}N) \text{~~...~~} \qquad (2)$$

where the state variable is S(k) (k = 1-N; where N is the number of the state variable), the reference state variable stored in the reference state variable storage device is ~~SO~~S0(k) (k = 1-N), correction values for the respective processing conditions ~~is~~are C(i) (i = 1-L), the influence function matrix indicating a relation between deviation of measured each state variable to its reference value and correction amount of the processing condition is T2(i, k) (i = 1-L, k = 1-N).

[0076] ~~[0036]~~ A formation example of the influence function matrix T2 is shown in an exemplary table of Fig. 4. When the punch reaction is, for ~~instance~~example, higher than the reference value by about 1%, the function of the influence function matrix T2 corresponds to that, using the above-described equation (2), the forming speed and blank holding force ~~are~~may be decreased by about 1% and 0.5%, respectively, and there ~~is~~may be little or no change for the metal mold temperature. ~~It has been known that each~~Each component of the influence function matrix T2 can be determined from a method to determine from the change (e.g., a sensibility analysis) of the

optimum forming condition to the change of various material characteristics using a forming simulation by a finite element method, similarly to the above-described influence function matrix T1.

[0077] ~~[0037]~~ ~~——~~Further, ~~there are a~~it is possible to utilize an exemplary method to statistically determine from a relation between state variable variation and processing condition, product quality (crack, creases, spring back, surface distortion, and the like) in actual mass production press process, a method to input actual measurement value on product quality into the press-forming device as instruction data and prepare and update using, for ~~instance~~example, a learning function by a neural network, or the like. ~~Note that~~The formation of the state variable or formulation method is not limited to the above described procedures/method, and ~~arbitral~~arbitrary setting ~~is~~(s) may also ~~adoptable~~be adopted.

[0078] ~~[0038]~~ ~~Here,~~An exemplary embodiment of a method to correct the forming conditions based on ~~three pieces of~~certain information that is based on the material characteristic inputted in advance, the material characteristic measured ~~just~~immediately before the press-forming, and the state variable during forming is ~~explained~~described below. It ~~is insufficient~~may be preferable to correct the forming conditions

based on not only one piece of information out of three pieces of the above-described information. Indeed, ~~therefore it is desirable to do so~~it may be preferable to make such correction based on ~~at least~~ two or more pieces of information to perform ~~highly~~a reliable control.

[0079] ~~[0039] Because it~~It is difficult or even impossible to avoid an influence of disturbance which ~~is~~may be difficult to predict in advance, such as a lubrication condition during forming or the like with only one piece of information of material characteristic inputted in advance or material characteristic measured just before press-forming. Furthermore, ~~there is a problem in~~it may be problematic that it is difficult or even impossible to separate influence due to material characteristic deviations with only the state variable during forming. This ~~is~~may be because the reduction effect of material characteristic deviations or product quality deviations caused by disturbance during forming ~~cannot~~may not be obtained satisfactorily.

~~[0040] -~~**Another Exemplary Embodiment**~~-~~

[0080] ~~As an~~According to another exemplary embodiment of the present invention, ~~a~~the press-forming device 5 shown in Fig. 1 ~~is~~can be prepared and the press-forming ~~is~~procedure may be

performed using a thin steel plate. As for the material characteristics, the sheet thickness and hardness ~~are~~may be measured for every blank, and typical mechanical properties attached by a material manufacturer for every coil are used for yield strength or 0.2% proof stress, tensile strength, and total elongation and inputted into a material characteristic input ~~means~~arrangement for every blank, respectively. As ~~a~~for the state variable provided during the forming, a punch reaction ~~is~~can be monitored using a load cell, the metal mold temperature ~~is~~can be monitored using a thermocouple and the forming speed, blank holding force are controlled based on the equations (1) and (2).

[0081] ~~[0041]~~ In the above-described exemplary procedure, a number of (e.g., 4) points of sheet thickness, yield strength, 0.2% proof stress, tensile strength, total elongation, and hardness ~~are~~can be used as the material characteristic value P(j) (j = 1-5), two points of forming speed, and blank holding force ~~are~~may be used as the processing condition C(i) (i = 1-2), and N points of punch reaction (N-1 point) for every punch stroke and metal mold temperature are used as the state variable S(k) (k = 1-N).

[0082] ~~[0042]~~ As for a raw material utilized for the exemplary procedure, a "150 mm" blank stamped from the same cold rolling

coil for deep drawing having an average thickness of 1.2 mm and a width of 1000 mm ~~is~~may be used to perform "50 mm" square cup drawing with a forming height of "40 mm". ~~Typical~~Exemplary mechanical properties and ~~the~~ reference values of the coil are provided in the table shown in Fig. 5.

[0083] ~~[0043]~~ ~~Standard~~Exemplary or standard processing conditions for the ~~typical~~exemplary characteristics of this material are provided in the table shown in Fig. 6. ~~Then, based~~Based on the actual measurement value for the sheet thickness and the typical mechanical properties of the coil inputted for every ~~one~~ sheet of the blank, an initialization of the processing conditions ~~are~~can be performed using the influence function matrix T1 ~~shown by the~~provided above in equation (1) and provided in the table shown in Fig. ~~7~~7, and the forming procedure is ~~started~~initiated.

[0084] ~~[0044]~~ During the processing procedure, the forming procedure is performed without changing the initialization during ~~forming in example 1~~a first exemplary procedure for the previously-described exemplary embodiment of the present invention~~, in other words,~~. For example, the forming conditions are set based on the material characteristics inputted in advance and the material characteristics measured before forming, and the forming is performed without using a state

variable during forming, and the forming speed and blank holding force set to be about constant.

[0085] ~~[0045] In example 2~~According to a second exemplary procedure of the present invention, the punch reaction and the metal mold temperature ~~are~~may be measured for about every 10 mm stroke until the maximum punch stroke (=forming height 40 mm)~~, taking the punch reaction and the metal temperature~~. The punch reaction and the metal temperature may be obtained at the time of obtaining ~~a good~~an acceptable product under approximately the same processing conditions by a trial pressing in advance as reference values of the state variable provided in the table shown in Fig. 8, using the influence function T2 provided in the table shown in Fig. 9, forming speed and blank holding force are adjusted with ~~the~~ equation (2). ~~In other words~~Indeed, the press conditions ~~are~~can be controlled using the material characteristics inputted in advance, the material characteristics measured before the forming, and the state variable during the forming.

[0086] ~~[0046] In example 3 of the present invention, using~~According to a third exemplary procedure of the present invention, a measured value of only sheet thickness and hardness for every one blank sheet can be used, without using material characteristics such as yield strength or 0.2% proof stress,

tensile strength, and total elongation~~, the punch reaction and the metal mold temperature are measured for every 10 mm stroke until the maximum punch stroke (=forming height 40 mm) similarly to the manner in embodiment 2, taking the punch reaction and the metal temperature at the time of obtaining a good product under the same processing conditions by a trial pressing in advance as reference values of the state variable shown in Fig. 8, using the influence function T2 shown in Fig. 9, forming speed and blank holding force are adjusted with the equation (2). In other words, the press conditions are~~. In this manner, the punch reaction and the metal mold temperature can be measured using such measured value for approximately every 10 mm stroke until the maximum punch stroke (e.g., a forming height 40 mm) similarly to the manner in the second exemplary procedure, taking the punch reaction and the metal temperature at the time of obtaining an acceptable product under approximately the same processing conditions by a trial pressing in advance as reference values of the state variable provided in the table shown in Fig. 8, using the influence function T2 provided in the table shown in Fig. 9, forming speed and blank holding force are adjusted with equation (2). In particular, the press conditions can be controlled using the material characteristics measured before forming, and the state variable during forming.

[0087] ~~[0047] In example 4 of the present invention, using only material characteristics inputted in advance: yield strength or 0.2% proof stress, tensile strength, and total elongation, similarly to embodiment 2, the punch reaction and the metal mold temperature are measured for every 10 mm stroke until the maximum punch stroke (=forming height 40 mm), taking the punch reaction and the metal temperature at the time of obtaining a good product under the same processing conditions by a trial pressing in advance as reference values of the state variable shown in Fig. 8, using the influence function T2 shown in Fig. 9, forming speed and blank holding force~~

[0088] ~~are adjusted with the equation (2). In other words, the press conditions are controlled using the material characteristics inputted in advance, and the~~

[0089] ~~state variable during forming.~~

[0090] According to a fourth exemplary procedure of the present invention, using the material characteristics inputted in advance, such as yield strength or 0.2% proof stress, tensile strength, and total elongation, similarly to the second exemplary procedure, the punch reaction and the metal mold temperature may be measured for every 10 mm stroke. Such measurement can be performed until the maximum punch stroke (for example, having a forming height of about 40 mm), taking the

punch reaction and the metal temperature at the time of obtaining a good product under the same processing conditions by a trial pressing in advance as reference values of the state variable provided in the table shown in Fig. 8, using the influence function T2 provided in the table shown in Fig. 9, the forming speed and blank holding force are adjusted with the equation (2). In other words, the press conditions can be controlled using the material characteristics inputted in advance, and the state variable during the forming.

[0091] ~~[0048]~~ As a comparison example, using the forming speed and blank holding force without changing the processing conditions to the reference material characteristics, the forming procedure is performed without correcting the reference processing conditions during the forming.

[0092] ~~[0049] The~~For example, the above-described forming experiment ~~is~~can be carried out by punching total of about 1000 pieces of blanks from the same coil, ~~percent~~the defective pieces due to the occurrence of cracks and creases ~~are~~can be compared as follows.

sheet thickness standard deviation : 5 ~~μm~~um

percent detective :

~~(Example 1~~(First exemplary procedure of the present invention) 0.9%

~~(Example 2~~(Second exemplary procedure of the present invention) 0.1%

~~(Example 3 of the present invention) 0.5%~~

~~(Example 4 of the present invention) 0.5%~~

(Third exemplary procedure of the present invention) 0.5%

(Fourth exemplary procedure of the present invention) 0.5%

(Comparative Example) 1.2%

[0093] ~~[0050]~~ The ~~percent~~percentage of the defective ~~is~~pieces can be reduced by changing the initialization of the processing conditions according to the deviation of the sheet thickness, and the percent defective is further reduced by adjusting the processing condition according to punch reaction and metal mold temperature during the forming.

[0094] ~~[0051]~~ Fig. 10 shows an ~~example~~elevation view of ~~a~~an exemplary cut plate package 100 supplied from a coil processing center, to which ~~an~~the IC tag 101 is attached. Information such as "tensile strength", "yield strength or 0.2% proof stress", "total elongation", "sheet thickness", "production date" and the like ~~are~~can be stored in the IC tag 101. The information is read ~~with~~or obtained using the material characteristic reader (IC tag reader) 9, and ~~is~~may be transmitted to the computation

device 21, thereby ~~saving~~reducing or eliminating the labor that would otherwise be incurred if the data were inputted manually.

[0095] ~~[0052]~~ ~~Fig. 11 shows an example to attach an IC tag 111 to a material coil 110. Also in the case of this example~~elevation view of an exemplary material coil 110 which includes attached thereto the IC tag 111. In this exemplary embodiment, information such as "tensile strength", "yield strength or 0.2% proof stress", "total elongation", "sheet thickness", "production date" and the like ~~is~~may be stored in the IC tag 111. Therefore, it ~~becomes~~may be possible to ~~save~~reduce the labor to manually input the material characteristics when the material coil 110 is pressed and the information obtained in an automated matter.

[0096] ~~[0053]~~ ~~Fig. 12 shows an example to attach a bar code 121 to~~elevation view of an exemplary embodiment of a cut plate material ~~120.~~120 to which the bar code 121 is attached. Information showing a product lot number ~~is~~can be displayed on the bar code 121. By reading the information with a bar code reader in the material characteristics reader, information relating to the corresponding material can be obtained from, for ~~instance~~example, a server computer on a network.

[0097] ~~[0054] Next, an example in the case of~~Further, another exemplary embodiment for performing the exemplary press-forming

~~is explained~~procedure is described below with reference to Fig. 13. In Fig. 13, a graph in which punch reactions and blank holding forces are expressed along the vertical axis, and the number of forming times ~~is~~are expressed along the horizontal axis. ~~In Fig. 13, a~~A black rhombus in Fig. 13 denotes a punch reaction during ~~one~~the time of forming.

[0098] ~~[0055]~~ In this ~~example~~exemplary embodiment, the punch reaction maximum value during the forming ~~is~~can be captured and stored in a storage arrangement that can be accessed by a computer for every ~~one~~ time of the forming. Further, the moving average of the punch reaction maximum values ~~is calculated~~can be determined, and an example of controlling to change the blank holding force when the punch reaction maximum value exceeds a prescribed value (in an example in Fig. 13, 500 ton ~~±~~± 10 ton) ~~is~~may be shown.

[0099] ~~[0056]~~ As a result, as shown in the exemplary illustration of Fig. 13, since the 10 points moving average value exceeds a permissible range, the forming ~~is~~can be carried out under reduced blank holding force from, e.g., fiftieth times. As a result, the punch reaction maximum value can be ~~kept~~maintained within the prescribed value, forming of ~~prescribed~~predetermined number of sheets can be achieved without the occurrence of a defective piece.

[00100] ~~[0057] It should be noted that in~~In the above explanation, an example in which the punch reaction maximum value during processing is taken in a computer for every one time of forming is shown, ~~but~~and it may be taken in for every prescribed time. Furthermore, in ~~an example~~the exemplary graph shown in Fig. 13, an example in which the blank holding force is reduced from the fiftieth times because the 10 point moving average exceeds a permissible range is shown~~, however, on the contrary~~. However, the blank holding force may be increased when the moving average value falls short of the permissible range.

[00101] ~~[0058]~~ In the above explanation, the blank holding force ~~is~~can be adjusted using the history of the punch reaction maximum values. However, exemplary embodiments of the present invention ~~is~~are not limited to ~~this~~such exemplary adjustments, and it is also ~~adoptable~~possible to adjust other processing condition, for instance, the forming speed or the like using ~~a~~the history of other state variables for instance, the metal mold temperature, the metal mold distortion amount, ~~or the like~~etc.

~~[0059] Other~~**Further Exemplary Embodiments**

[00102] As ~~explained~~described above, the control computer ~~22 includes~~arrangement 22 can include a computer CPU or mathematic processing unit (MPU), RAM, ROM, ~~RAM,~~ and the like, and ~~a~~the exemplary embodiment of the press-forming method ~~of~~according to the present embodiment ~~is realized~~can be employed, e.g., by operating a computer program/software arrangement stored in the above-described RAM, ROM, or ~~the like~~other storage arrangements.

[00103] ~~[0060]~~ Accordingly, the computer program ~~itself realizes the function of the above-described embodiment, which constitutes~~/storage arrangement, when executed by the computer arrangement 22 or another processing arrangement, can cause the performance of the exemplary functions of the exemplary embodiment of the present invention. ~~As a program transmission medium,~~To transmit the computer program/software arrangement, it is possible to use a communication medium (e.g., wire circuit such as optical fiber or wireless ~~circuit~~arrangement or the like) in a computer ~~net work~~network system (e.g., local area network - LAN, wide area network - WAN - such as ~~internet~~the Internet, wireless communication network or the like) ~~to propagate and supply program information as a carrier wave can be used~~.

[00104] ~~[0061]~~ ~~—~~Further, ~~a means supplying~~ the above-described computer program/software arrangement can be provided to a computer, for ~~instance, a storage medium storing such a program composes the present invention. As such a storage medium, for instance,~~example, via a storage medium that is configured to store such computer program/software arrangement. Such storage medium can include a flexible disc, hard disc, optical disc, magneto-optic disc, CD-ROM, magnetic tape, nonvolatile memory card, ROM, ~~or the like can be used~~etc.

[00105] ~~[0062] The present embodiments are to be considered in all respects as illustrative and no restrictive, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof.~~

Industrial Applicability

[00106] ~~[0063]~~ ~~—~~According to the exemplary embodiments of the present invention, it is possible to obtain ~~appropriate~~certain processing conditions ~~avoiding~~to avoid an influence due to unpredictable deviation factors such as variation in material characteristics, environmental change, lubricity between a metal mold and work, surface property, ~~and~~

~~the like~~etc., and it is possible to ~~always~~ obtain a favorable product.

[00107] The foregoing merely illustrates the principles of the invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous systems, arrangements, computer programs, procedures and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the present invention. In addition, to the extent that the prior art knowledge has not been explicitly incorporated by reference herein above, it is explicitly being incorporated herein in its entirety. All publications referenced herein above are incorporated herein by reference in their entireties.

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Rendering set	Standard

Legend:	
Insertion	
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Padding cell	

Statistics:	
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